



**Carnegie Mellon  
Software Engineering Institute**

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# **Organizational Considerations for the Estimating Process**

## **Bob Ferguson**

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# Learning Objectives

Purpose of estimating

Contents of a good estimate

Process factors for good estimates

Organizational Risk Factors



# Typical “Estimating” Problems

“My manager would not approve the initial estimate”

“The project doubled in size after the estimate.”

“The new CASE tool did not work correctly and slowed us down.”

“We had no estimating tool at the time of the estimate.”

“I lost some developers and had to find replacements.”

“Some people were assigned to the project charge number before the work started.”

**Politics**  
**Sizing**  
**Model**

**Productivity**  
**Process**



# Budgeting

*Budgeting is different from estimating*

Budget determines a value proposition.

- I want to build my own house on a piece of land I own.
- I can afford to invest \$300,000 in this house.
- I can make tradeoffs in the requirements to achieve this number.

Preliminary estimate

- I know the cost-basis of a house, similar to one I want, was \$150/sq-foot. Since my budget is \$300K. I should plan a house that is a bit less than 2000 sq-feet.

The budget can come before the requirements.

- My house needs 3 bedrooms and an art studio.



# The Estimate is Not the Plan

The estimate describes

- What it will cost in terms of how much work is required
- How long it will take for the assigned number of people.
- A curve that shows the relationship between people and time
- Which inputs and assumptions had the greatest effect

# Multiple Purposes

Development of budgets

**Project planning**

**Project change management**

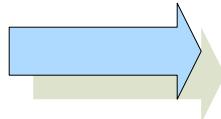
Bidding on an RFP

Preparation of an RFP

Strategic planning

# Outline

Purpose of an estimate



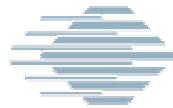
Create a standard for estimates

Estimating inputs

Process factors for good estimating

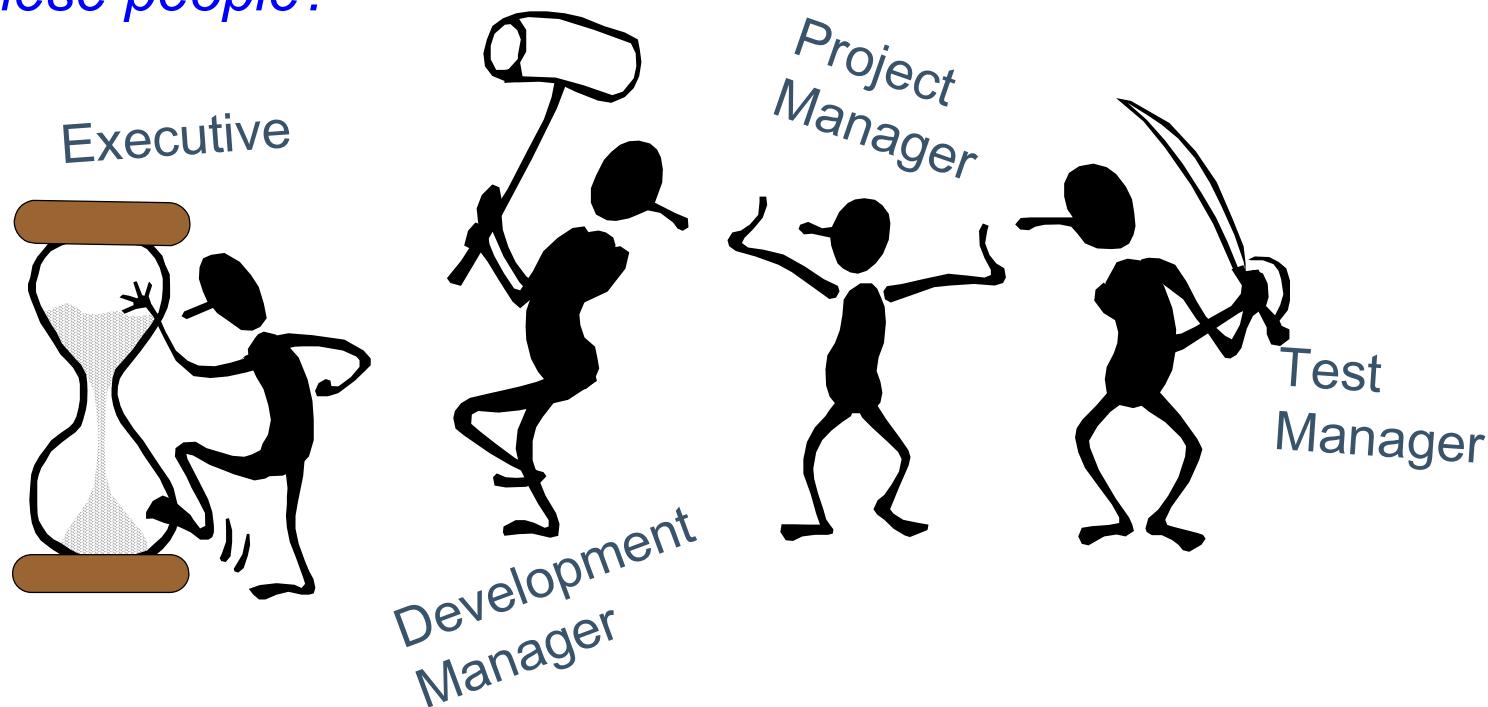
Risk factors in estimating

Wrap up



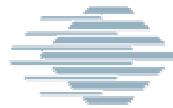
# Begin with the End in Mind\*

*How does the estimate affect the actions and decisions of these people?*

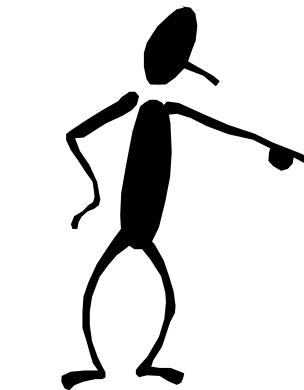


Principle: It's easier to make a process or procedure stick if it serves several different people.

*Steven Covey, Seven Habits of Highly Effective People*



# Estimation Process Serves



## Project Manager

Must plan and control the project.

*Re-plan* when there are changes.

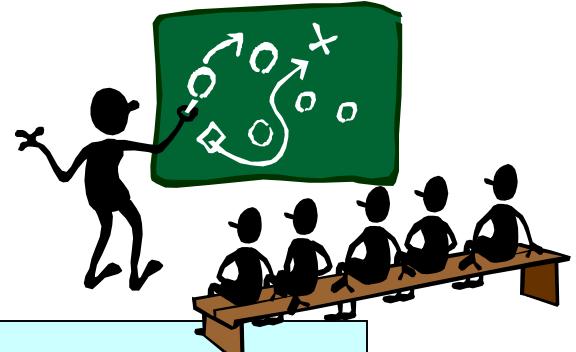


## Estimator

Trained to the process.  
Access to project history

## Senior Manager

Allocate resources  
Reprioritize work  
Trusts the estimate.



## Project Team

Check assumptions

# Project Manager

**Role:** Has the direct responsibility for project success.

Uses the estimate for **planning**

- Scoping, tasking, staffing, scheduling, constraints, risk planning

Uses the estimate to help with **change management**

- Why is the estimate now inadequate?
- Additional knowledge acquired during project
  - Complexity, resources, process capability & capacity, etc.
- Changed constraints
- Changed scope
- Risk event



# Executive

**Role:** Allocate resources and working capital according to business priorities.

**Uses the estimate to:**

- Assess affordability, cost / benefit
- Prioritize work among competing projects
- Schedule and allocate resources and working capital
- Respond to change requests by
  - Reprioritize and reschedule projects, and/or
  - Reallocate resources

**Estimating Needs:**

- Costs, resources, duration, risk and possible tradeoffs

# Estimator

**Role:** Accountable for making estimate, training others to estimate.

**Identifies** critical project factors that drive the estimate.

**Uses** historical estimates and project data

- Formulate current estimate
- Improve estimating process and methods
  - Identify and modify adjustment factors
  - Identify constraints
  - Validate estimating models
- Post project reviews to understand influencing factors

**Values:** accuracy, productivity, professional growth



### Scoping

- Deliverables
- Requirements
- Complexity
- Lifecycle



### Constraints

- Cost, Schedule
- Resource limits
- Other

### Directives

- policy, publication ...

## Estimating

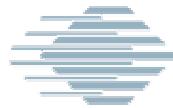
### Resources

- Skilled people
- Tools, methods
- Project history

# Estimating Context

### Estimate

- Size, defects, costs, duration, staffing
- Documented inputs , assumptions
- Estimating method
- Comparable projects
- Sensitivity analysis



# Estimating Process Outputs

## Purpose of the Estimate

Those things with numbers that we can get:

- Total and external costs,
- Duration,
- Workforce size and buildup
- Size,
- Defects,
- Productivity.

Assumptions and constraints considered

Project Lifecycle

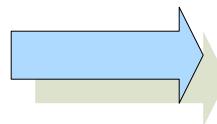
Estimating method, tools utilized, comparable projects

Person who did the estimate

# Outline

Purpose of an estimate

Create a standard for estimates

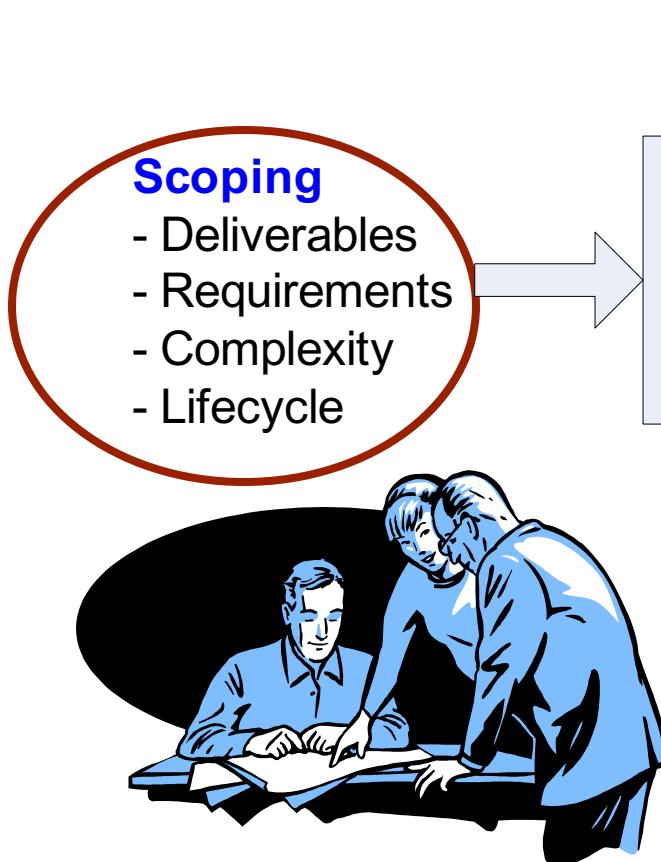


Estimating inputs

Process factors for good estimating

Risk factors in estimating

Wrap up



### Scoping

- Deliverables
- Requirements
- Complexity
- Lifecycle

### Constraints

- Cost, Schedule
- Resource limits
- Other

### Directives

- policy, publication ...

## Estimating

### Resources

- Skilled people
- Tools, methods
- Project history

# Estimating Context

### Estimate

- Size, defects, costs, duration, staffing
- Documented inputs, assumptions
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- Sensitivity analysis



# Scoping Data

Scope Elements

- Size

Project Lifecycle

Complexity factors

***Where do you get this data?***

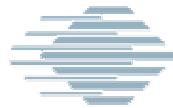
# Defining Scope

Why are we doing this project?

What objectives should the project accomplish?

What are we responsible to deliver?

- Software
- Documentation
- Hardware and other deliverables
- Demonstration and marketing events
- Installation and deployment services
- Formal external reviews



# Size the Scope

From the list deliverables,

- Identify required configuration items
- Classify as needed (e.g. new, reuse, environment)
- Size items and identify uncertainty ranges for size

***Do you need size for  
every single configuration item?***

No, but I'd suggest requirements, code, test cases and any externally delivered documentation.

# Lifecycle Inputs

## Release Planning from Product Management

- Requirements and release content
- Customer and market data
- Tradeoff goals

## Product development lifecycle

- Phasing
- Standard intermediate deliverables
- Tailoring information
- Transition to manufacturing and deployment



# Complexity Factors

Technical complexity factors

New aspects of business domain

Organization and geography

Certain constraints coming from the customer

- Dates
- Customer environment



*Complexity factors increase risk or uncertainty.*



# Estimating Context

## Scoping

- Deliverables
- Requirements
- Complexity
- Lifecycle

## Constraints

- Cost, Schedule
- Resource limits
- Other

## Directives

- policy, publication ...

## Estimating

## Estimate

- Size, defects, costs, duration, staffing
- Documented inputs, assumptions
- Estimating method
- Comparable projects
- Sensitivity analysis

## Resources

- Skilled people
- Tools, methods
- Project history





# Constraints and Directives

## Constraints

- Budget and schedule constraints and tradeoffs
- Resource limits
  - Restricted availability of people, facilities, etc.

## Directives

- Purpose of the estimate
- General policy about projects and estimation
- What to include for publication
- Additional requirements or changes for internal use

Directives may be “messages” to the project manager.

- Use Tom’s lab for testing.
- We have to bring this project in within 15 months.
- *The point is to record these directives with assumptions.*

# Resources

## People and skills

- Estimate will depend on availability of skilled people to perform the project work.
- New hires will extend the project duration and increase costs.

## Tools and methods

- If tools and methods for the project are not stable, then extra time will be required for learning.

## Project history database

- Data about team productivity
- Information about complexity factors
- Information about risk

# Outline

Purpose of an estimate

Create a standard for estimates

Estimating inputs



Process factors for good estimating

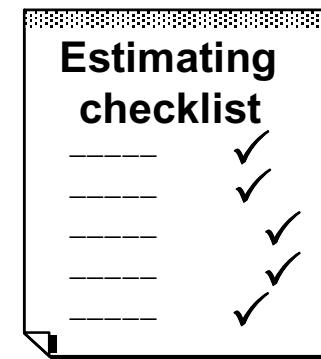
Risk factors in estimating

Wrap up



# Estimating Process Steps

1. Define the scope
2. Technical analysis
3. Business analysis (optional)
4. Follow-through



1. Park, Robert, "Checklists and Criteria for Evaluating the Cost and Schedule Estimating Capabilities of Software Organizations," SEI-95-SR-005

# Technical Analysis

## Modeling

- Document inputs and derivation of inputs.
- Document comparable projects and rationale.

## Adjust Estimate

- Accounting for factors not addressed by the model.
- Eliminating model activities and elements that do not apply.
- Project staffing profile requirements rate adjustments.

Create auditable documentation and rationale for each adjustment.



# Business Analysis

Adjust estimate to proposal or bid.

- “Bid-to-win”
- Cost-plus
- Incentive contract
  - Pays more for early completion
  - Pays incentive for reduced cost

Risk assessment

- Risk assessments.
- Risk graphs.
- Bid memorandum with parameter-by-parameter explanation of the risks.



# Follow-Through

## Estimate to Complete

- Updated size estimates.
- Updated reuse estimates.
- Updated parameter values and rationales for changes.
- Revised project estimate.
- Cost to complete.
- Schedule to complete.

## Post-Project Review and Data Collection

- Resulting size, reuse, and environmental values
- An analysis of differences between results and estimate.
- Updated and recalibrated cost model database.
- Lessons learned.



# The Estimate is Not the Plan

The estimate describes

- What it will cost in terms of how much work is required
- How long it will take for the assigned number of people.
- A curve that shows the relationship between people and time
- Which inputs and assumptions had the greatest effect

How do you plan?



# Mapping the Estimate to the Plan

The WBS was chosen as part of the estimating process.

3-step allocation method

- Allocate costs to deliverables (supports earned value).
- [Allocate defect information to deliverables]
- Allocate schedule to milestones.
- Map people-skills to tasks.

*You may need to iterate through the steps in order to build a schedule.*

Create baseline plan and charts that map estimated values to schedule for reporting.

# Estimating Process Quality Objectives

Organization has confidence in **accuracy** of the estimate.

Organization provides clear policy on **when** to estimate.

Staff know **who** provides the estimate and expertise.

Staff know **what** the estimate contains and how to use it.

The estimate is provided in a familiar format.

## 6 Requisites for Reliable Estimating Processes

- A corporate memory (database, repository)
- Structured processes for estimating size and reuse
- Mechanisms for extracting history from projects
- Audit trails (values used to estimate are recorded)
- Integrity in dealing with cost and schedule constraints
- Data collection and feedback processes that foster capturing and interpreting data from work performed

Park, Robert E., “Checklists and Criteria for Evaluating the Cost and Schedule Estimating Capabilities of Software Organizations”,  
SEI-95-SR-005



## 7 Indicators of Estimating Capability

- Management acknowledges its responsibility for developing and sustaining an estimating capability.
- The estimating function is supported by budget.
- Estimators are equipped with tools and training needed for reliable estimating.
- People assigned as estimators are experienced and capable.
- Recognition and career paths exist such that qualified people want to serve as estimators.
- Process improvement resources and funds are committed to improving the estimating process.
- The estimating capability of the organization is tracked and evaluated.

Park, *op. cit.*

# Organizational Behaviors

Estimators have experience at estimation as it applies to

- Business domain,
- Project life cycle,
- Capabilities
- And our other processes (budgeting, etc.)

Project managers know the people who estimate and trust them.

Managers believe the estimates and act accordingly.

- Resource allocation follows the estimate.
- Work can be reprioritized based on the estimates.



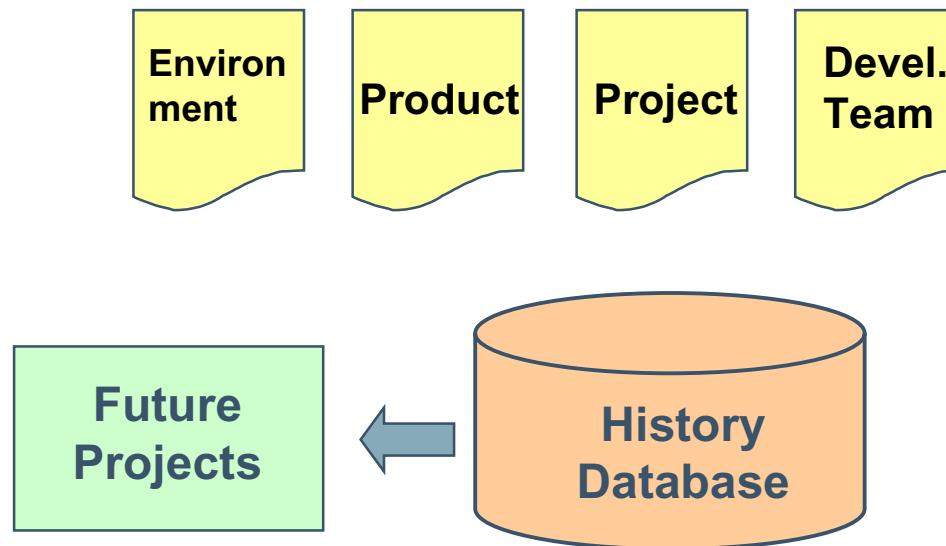
# Historical Database

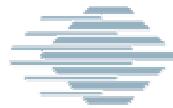
Integral to the estimating process.

Estimators have an active role in specifying and sustaining the estimating history.

Database contains a useful set of completed projects.

Any excluded data is clearly identified.

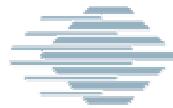




# Project Management Metrics

Milestone	Plan-date	Actual-date	Plan-cost to date	Actual-cost to date
Req. Accept.	1/31/04	2/12/04	(Effort or \$\$)	
Project Plan Approval	1/15/04	1/22/04		
CDR	4/30/04			

Sample table for diagram on previous slide



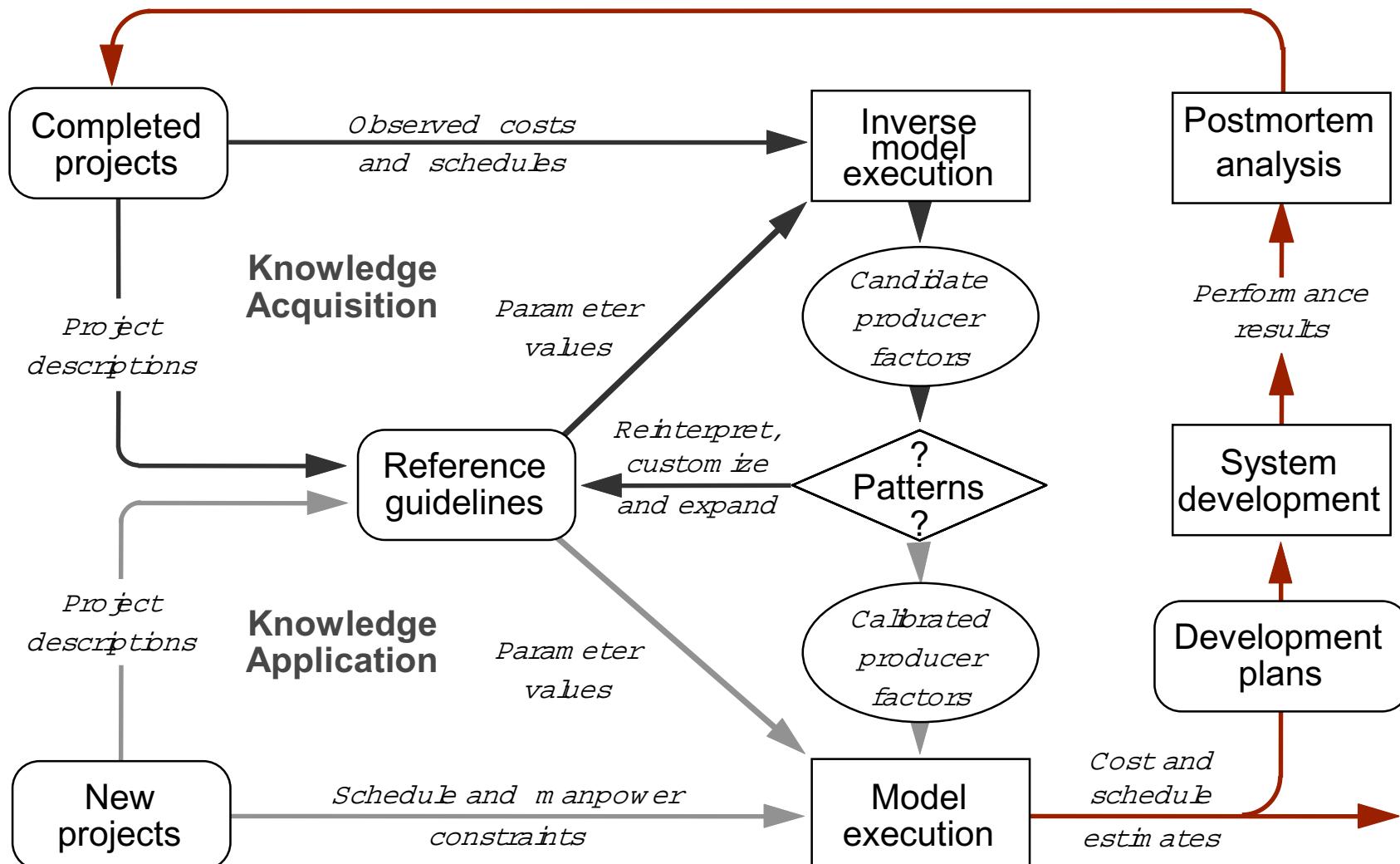
# Project Product Metrics

Item	Estimated	Actual	Unit
Code-Size	100	113	KLOC
Design-Defect	400	373	Count
Test-Defect	2000	2211	Count
User-Doc	300	245	Pages

Sample table for diagram on previous slide



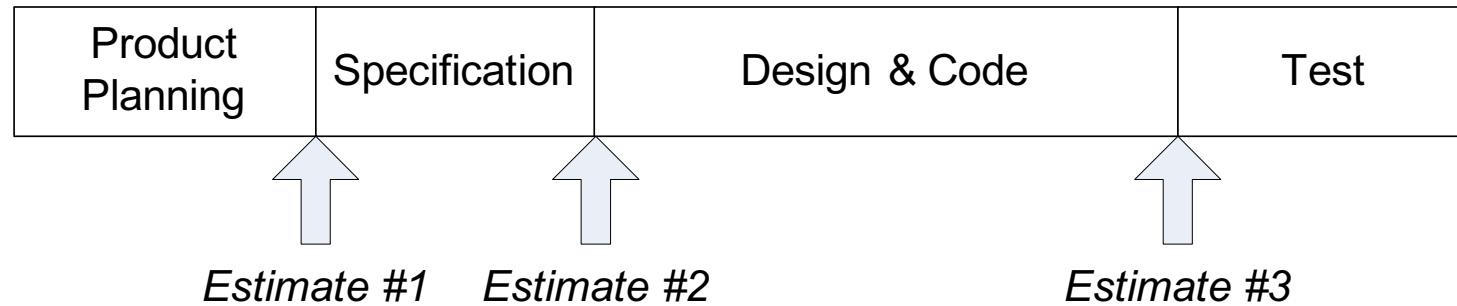
# Parametric Estimating Process





# Estimate more than once?

A Product Development Life Cycle



*Why would you do this?*



# The Estimating Role

Estimators can take responsibility for many estimating chores.



Development of budgets

Project planning

Project change management

**Bidding on an RFP**

**Preparation of an RFP**

Strategic planning

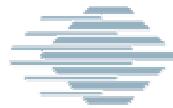
# The CMMI Says:

Estimating appears in

Project Planning

- SG 1 Estimates of project planning parameters are established and maintained.
  - Project planning parameters include all information needed by the project to perform the necessary planning, organizing, staffing, directing, coordination, reporting and budgeting.

And is supported by the Generic Goals  
(specifically GG2 and GG3)



# CMMI Generic Goals

## GG2: Institutionalize a Managed Process

- Establish an organizational **policy**
- Plan the process
- Provide resources
- Assign responsibility
- Train people
- Manage configurations
- Identify and involve relevant stakeholders
- Monitor and control the process
- Objectively evaluate adherence
- Review status with higher level management

## GG3: Institutionalize a Defined Process

- Collect improvement information

# Sample Estimating Policy

- **Process:**

Product development projects will use “SP10: Project Estimate” to provide needed data to the work plan.

- **When:**

The Project Estimate will be created within 5 days of acceptance of requirements (ref. SP1: Requirements).

- **Who:**

Project Estimate will be prepared by a staff member who has completed Estimating Training and has participated in estimating at least one other project.

- **Review:**

Satisfactory performance of Project Estimate will be assessed at Annual Product Development Quality Review

# Outline

Purpose of an estimate

Create a standard for estimates

Estimating inputs

Process factors for good estimating



Risk factors in estimating

Wrap up



# Product Management

Is this a one-time build?

- Have to have all the requirements at once.
- Customer may “gold-plate” the request.
- Little development time to learn the customer domain

**Higher  
Risk**

Or multiple releases?

- Negotiate features by release.
- Provides time to learn about customer domain.

**Lower  
Risk**

Risk mitigation:

- Two estimates – budget and after specification
- Double the time allocated for requirements analysis



# Maintenance or Development?

Development never ends

Same team does maintenance and development

Same cost account used for maintenance

Project leader and technical leader are the same

**Higher  
Risk**

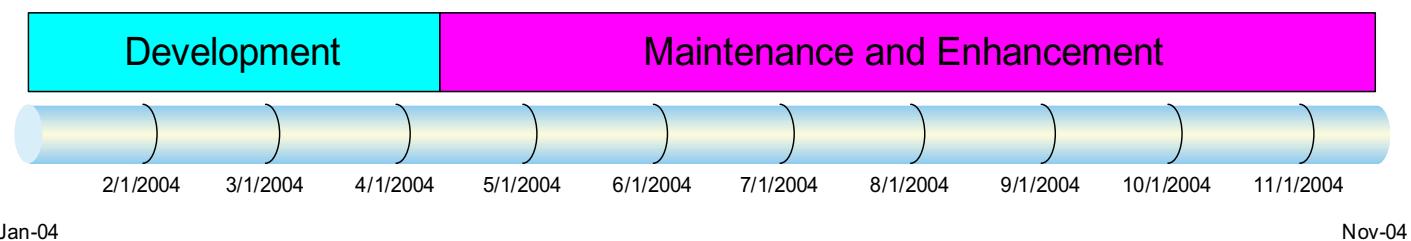
Planned release schedules for development projects

Professional project management

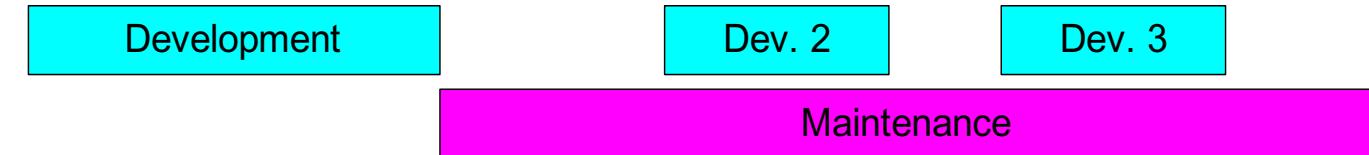
Separate cost accounts

**Lower  
Risk**

This?



Or this?





# History Database Risks

“Every project is different.”

Organization has no set milestones.

Only code and test have history.

Database contains no similar project.

Project history is collected long after project.

**Higher  
Risk**

Common set of milestones is in history database.

Small set of WBSs are available and every project is tailored from one of these.

History database has similar projects.

Project history is recorded as project milestones and deliverables are completed.

**Lower  
Risk**



# People Risks

Everyone estimates his own project.  
Estimating is not part of every project.  
Limited access to historical data.  
Estimator has limited experience.  
Estimator has limited access to other estimators.

**Higher  
Risk**

Estimator role is an official, recognized one.  
Estimator has access to other estimators.  
Estimator understands business domain.  
Estimator has full access to past projects.  
Estimator has training and experience.

**Lower  
Risk**



# Principles of Estimating

Estimates are made by people, not by models.

- They require reasoned judgments and commitments to organizational goals that cannot be delegated to any automated process.

All estimates are based on comparisons.

- When people estimate, they evaluate how something is like, and how it is unlike, things that they or others have seen before.

Before people can estimate, they must acquire knowledge.

- They must collect and quantify information from other projects, so that they can place their comparative evaluations on demonstrably sound footings.

Park, Reference 3

# References

- § Jones, Capers, *Estimating Software Costs* , McGraw-Hill, 1998
- § Park, Robert, "Checklists and Criteria for Evaluating the Cost and Schedule Estimating Capabilities of Software Organizations," SEI-95-SR-005
- § Park, Robert, "A Manager's Checklist for Validating Software Cost and Schedule Estimates," CMU/SEI-95-SR-004
- § Park, Robert, *et. al.* "Software Cost and Schedule Estimating: A Process Improvement Initiative,"